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SEE ENERGY BRIEF

Monthly Analysis

Electricity Interconnections in SE Europe Pave the Way for an Integrated Regional Market

Introduction

The energy sector constitutes a major economic activity for most countries in SE Europe with a significant contribution to infrastructure investment and market activity. Even more important is the geopolitical role often associated with energy issues as they normally involve bilateral or even trilateral cooperation. A number of major cross-border energy projects are currently under development in the region, including gas and electricity interconnections, but also some very large projects on renewable energy (e.g. wind farms, photovoltaic plants, geothermal plants, biomass units, etc.) and large-scale energy efficiency interventions, especially in the building sector.

As renewable electricity production is growing, it is becoming increasingly clear that the SE European region is in need of more and better electricity interconnections, something that is especially visible in island regions, such as Greece and Cyprus. Advancing international electricity interconnections especially between Italy and Western Balkans and between mainland Greece and the Israel-Cyprus-Crete axis is becoming a priority in view of the fast advancing electricity market integration in the region.

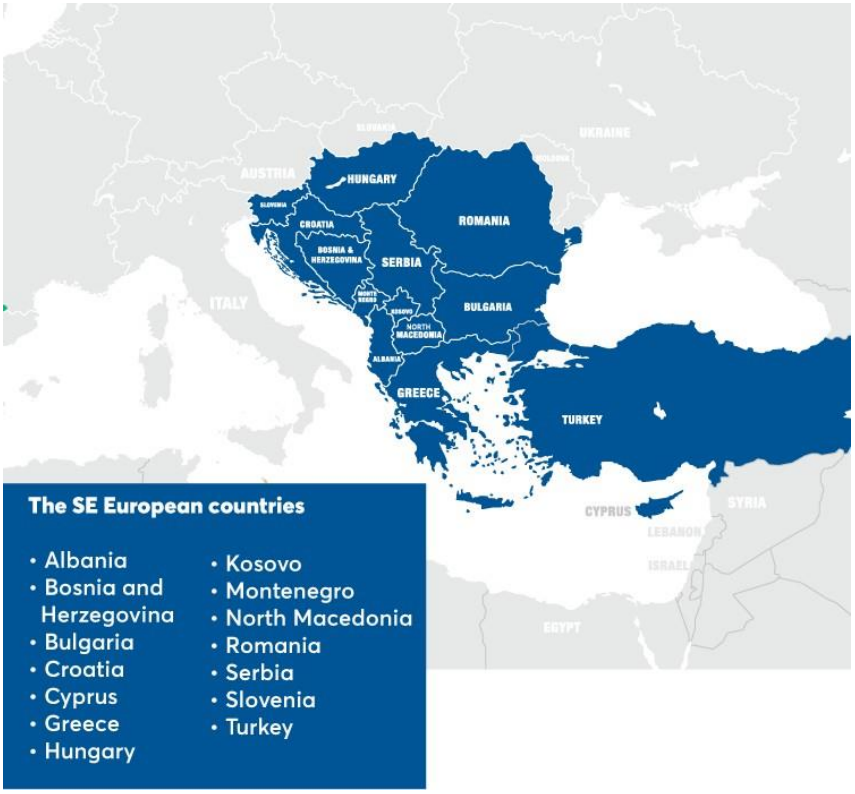
This Monthly Analysis focuses on the latest developments concerning the ongoing and planned electricity interconnections in the wider SE European region, highlighting their importance, in parallel with the increasing RES penetration, for achieving the goal of an integrated regional market.

The SE European Region

In order to facilitate our approach, we need to define and understand the geography of the SE European region. Thus, we consider the broader region as consisting of four main blocks, as follows: (a) West Balkans, (b) EU member countries - which include the Eastern Balkans (Romania, Bulgaria, Greece, Hungary) and the north of West Balkans (Croatia, Slovenia), (c) Türkiye and (d) the East Mediterranean (Cyprus, Egypt and Israel), as also analysed in IENE's reference study "SE Europe Energy Outlook 2021/2022". **(1)**

Although strictly not part of SE Europe, Israel and Egypt, located in the East Mediterranean, are in the process of developing close energy ties with the broader region and hence, they are included in the current Monthly Analysis.

Map 1: The SE European Region as Defined by IENE



Source: IENE

Planned Electricity Interconnections in SE Europe

A key area of interest for SE Europe and an opportunity for bilateral or trilateral energy partnerships concerns regional cooperation in the Eastern Mediterranean in order to address supply issues by building electricity interconnectors between Europe, Asia, and Africa. These can be used to transmit electricity produced by a growing RES share, but also for balancing purposes, thus spearheading the green recovery in a region that is particularly impacted by climate change.

One such project, the Great Sea Interconnector, which was first conceived in 2010 as "EuroAsia Interconnector", already enjoys European backing, while another, the Greece-Egypt Power Interconnector, has been approved by EU regulatory authorities and is part of the ten-year development plan of the European Network of Transmission System Operators for Electricity (ENTSO-E)[1]. A third one, the EuroAfrica Interconnector, has also been approved by EU regulatory authorities and has received political support from Egypt, Cyprus, and Greece.

[1] The project, whose subsea route lays within the officially demarked Greece-Egypt Exclusive Economic Zone, was successfully included in ENTSO-E TYNDP 2022 as project number 1048, 1048 – Greece - Africa Power Interconnector (GAP Interconnector) project sheet, https://tyndp2020-project-platform.azurewebsites.net/projectsheets/transmission/1048

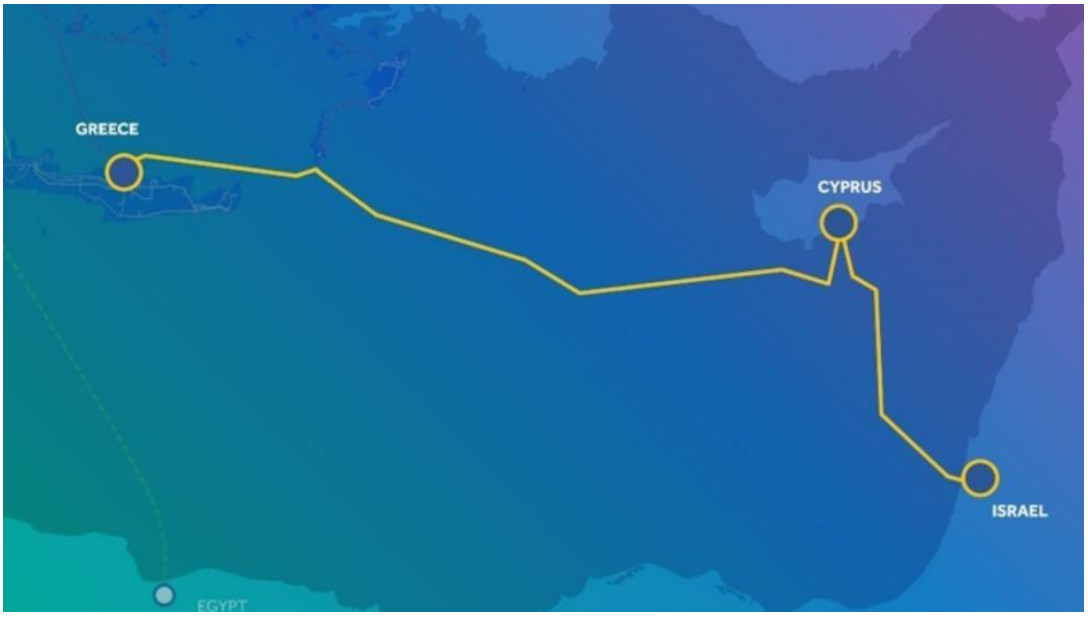
All the above interconnectors have the benefit of creating new important corridors to transmit sizeable electricity volumes, produced from various energy sources, to Europe.

The Great Sea Interconnector

This ambitious project is geared towards knitting together the electricity grids of three nations – Israel, Cyprus, and Greece – employing cutting-edge high-voltage direct current (HVDC) submarine cables. At its core, the Great Sea Interconnector seeks to establish a seamless conduit for the exchange of electricity among these nations, heralding a new era of extensive energy cooperation and fortifying the energy security of each participating country.

The installation of the project's cable is planned to begin in 2025 and be completed by 2027. The Crete-Cyprus grid interconnection, a project budgeted at €1.9 billion, will cover a distance of 898 kilometers. The wider project's two sections, dubbed the Great Sea Interconnector, planned to link the Greek, Cypriot and Israeli electrical grids, will cover a total distance of 1,208 kilometers. Favorable results of a cost-benefit analysis conducted by the Greek power grid operator IPTO on the Greece-to-Cyprus segment of the Great Sea Interconnector came as a boost for the project's development prospects.

Map 2: The Great Sea Interconnector



Source: Great-Sea-Interconnector.com

The significance of the Great Sea Interconnector amplifies when considering its broader implications. By interlinking the electricity grids of Israel, Cyprus, and Greece, this project not only fosters regional synergy but also lays the foundation for a resilient energy network spanning the Eastern Mediterranean. Through this collaboration, these nations can optimise their energy resources, balancing supply and demand effectively, and ensuring a stable, uninterrupted energy supply for their citizens and industries.

The project has a huge geopolitical interest as it will link Cyprus and Israel to the European grid network. This is the reason why the project has attracted very high financial contribution (€650 million) from EU's Connecting Europe Facility.

However, the Great Sea Interconnector's impact extends far beyond the regional realm. A fundamental aspect of this initiative lies in its strategic alignment with the wider European energy landscape. By integrating with the European electricity grid, the project creates pivotal interconnections between the East Mediterranean and continental Europe. This interconnectedness holds immense promise, enabling the smooth, cross-border flow of electricity. This integration not only enhances the energy security of the participating nations but also reinforces the collective resilience of the European energy grid. It strengthens the foundation for a collaborative, pan-European energy market, fostering stability and sustainability in the face of evolving energy demands.

Cyprus, being at the center of the Great Sea Interconnector, benefits enormously, since by linking with Crete's electricity grid it gains access to the European grid, thus enabling itself to end its energy-island status.

Additionally, the Great Sea Interconnector fosters economic growth and stability in the host countries – Israel, Cyprus, and Greece. The construction and operational phases of the project will attract substantial investments, stimulating local economies, creating job opportunities, and encouraging technological advancements.

In essence, the Great Sea Interconnector transcends its role as a mere infrastructure project. It symbolizes a transformative force, shaping the energy landscape of the nations involved, fostering regional collaboration.

The EuroAfrica Interconnector

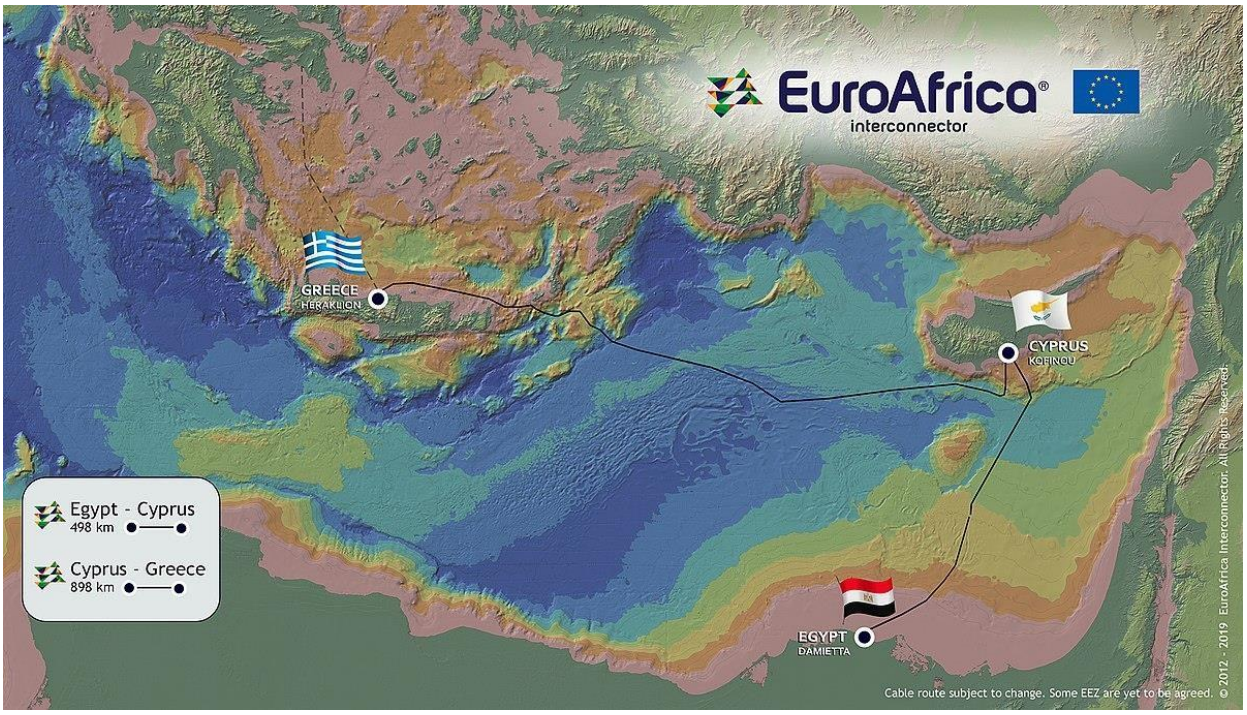
The EuroAfrica Interconnector stands as a pioneering venture, interlinking the electricity grids of Egypt, Cyprus, and Greece in Europe. This integration is made possible through an extensive subsea DC cable and onshore converter stations, boasting a substantial total capacity of 2,000 MW and spanning an impressive distance of 1,396 km. Serving as a robust energy conduit, this project serves as a dependable alternative for the transfer of electric energy to and from Europe **(2)**.

Endorsed by the European Union, the EuroAfrica Interconnector embodies a multitude of strategic goals. Firstly, it marks a significant milestone in eradicating Cyprus's energy isolation, eliminating its status as the last EU member state devoid of any electricity or gas interconnections. Moreover, the project ensures the secure supply of electricity to the European Union. By creating a dedicated electricity route from Egypt to

Cyprus and Greece, this initiative guarantees a stable supply sourced from the gas reserves of Cyprus and Egypt, alongside renewable energy sources (RES), thus advancing the completion of the European Internal Market.

Additionally, the EuroAfrica Interconnector strengthens energy security for Cyprus, Crete, and the entire EU system. Through the seamless integration of Cyprus and Crete's isolated energy systems with Egyptian and European networks, it facilitates an uninterrupted, multidirectional flow of energy, fortifying energy supply chains. According to the EuroAfrica Interconnector's website, the implementation dates for the commencement of stage 1 of the electricity interconnection between Egypt, Cyprus, and Greece are by December 2028 for the section of Cyprus-Egypt and by early 2029 for the section of Cyprus-Greece (Crete).

Map 3: EuroAfrica Electricity Interconnector



Source: EuroAfrica Interconnector Ltd.

In alignment with the EU's overarching goal, the EuroAfrica Interconnector contributes significantly to achieving the target of 10% electricity interconnection between member states. Moreover, its socio-economic impact extends to the local level, generating employment opportunities and supporting communities, thereby enriching the social fabric of the regions involved. The EuroAfrica Interconnector, thus, stands not only as an energy infrastructure project, but also as a transformative force, shaping the energy landscape and fostering collaboration, growth, and sustainability **(3)**.

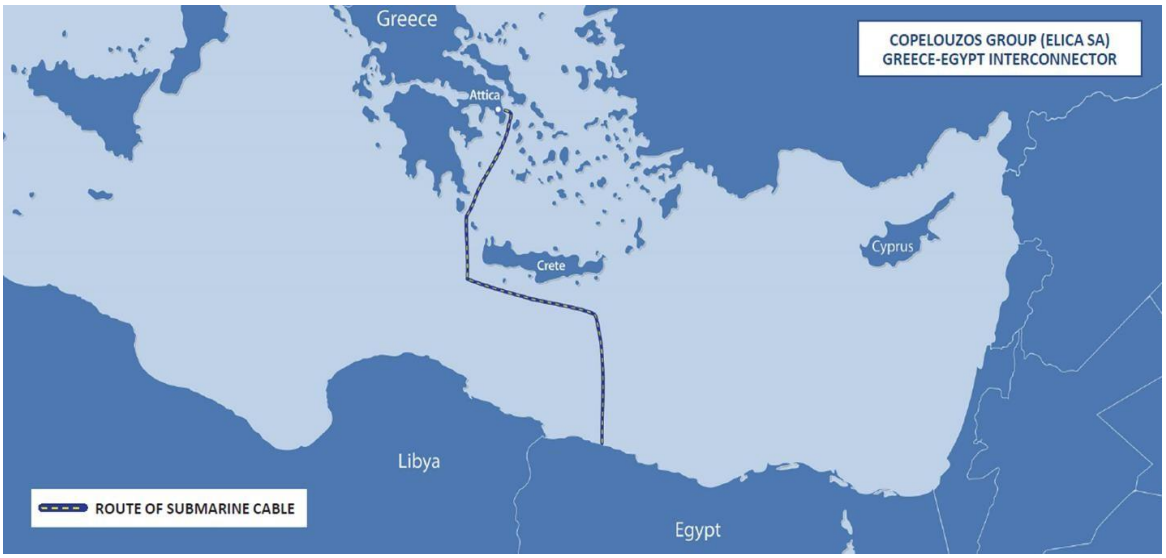
The GREGY project

Elica S.A., a member of the Copelouzos Group, a major Greek energy group, is spearheading this project for the electricity interconnection between Egypt and Attica, Greece. This initiative, endorsed by both Greece and Egypt, as well as the European Commission, stands as a significant step towards enhancing energy connectivity. The project, known as "GREGY project", has already been approved for inclusion in the 6th PCI/PMI project list. It proposes a direct link between Egypt and mainland Greece, eliminating the need for intermediate supply points.

At the heart of GREGY, it is a state-of-the-art submarine electricity cable with bi-directional power transmission capabilities, boasting a substantial budget of €4.2 billion. This high-tech cable will harness electricity from Egypt's RES, benefiting residential consumers and businesses not only in Greece, but also in neighboring European countries **(4)**.

GREGY aims to transmit 3,000 MW of electricity over a distance of 954 km, facilitating the replacement of 4.5 bcm of natural gas annually. This transition will result in a significant reduction of CO_2 emissions, slashing 10 mt per year. Copelouzos Group plans to establish renewable electricity plants of some 9.5 GW capacity in Egypt, making a substantial impact on the region's energy landscape **(5)**.

Map 4: The GREGY project



Source: IPTO

A total of 24 companies have submitted Expressions of Interest to Elica S.A. for a first-round tender offering a contract to conduct studies on the project. Objectives of these studies include determining an optimal choice for the interconnection's subsea cable route as well as delivering technical and cost-benefit analyses for the interconnection project.

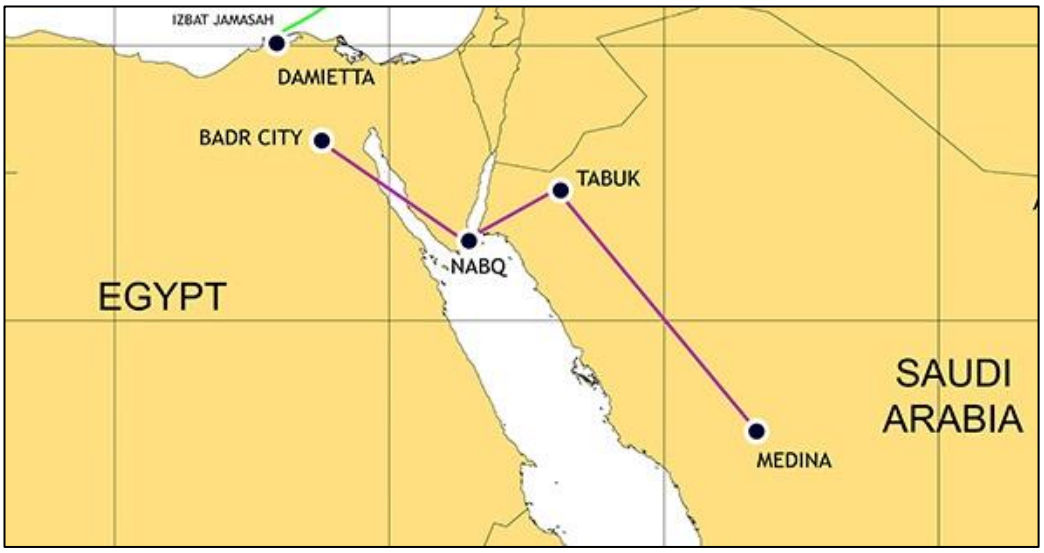
Embracing the EU's vision of green energy corridors from south to north, GREGY serves as a pivotal component of the EU's Global Gateway infrastructure development initiative. Valued at over €3.5 billion, this project not only fosters energy diversification but also aligns with the European Union's commitment to sustainable, environmentally friendly energy solutions.

The Greece-Saudi Arabia interconnector

One of the significant breakthroughs in the realm of regional energy cooperation is the recent agreement between Greece and Saudi Arabia to establish a vital interconnector. This monumental step has been marked by the mutual consent of the two governments. On September 27, 2023, the Kingdom of Saudi Arabia and Greece have inked a historic deal, culminating in the creation of a jointly-owned company. This venture is set to bridge the power grids of the two nations, paving the way for an interconnected energy network. **(6)**

The primary objective behind this pioneering initiative is to facilitate the supply of clean energy from the Middle East to Europe. By forging this collaboration, both countries are poised to play a pivotal role in bolstering the global clean energy transition. The establishment of this interconnector not only signifies a remarkable leap in diplomatic relations but also underscores the shared commitment of Greece and Saudi Arabia towards sustainable energy solutions. The proposal for a Greece-Saudi Arabia Interconnector follows an agreement between Saudi Arabia and Egypt for the construction of an electricity interconnector between the two countries, which is now 60% complete (see Map 5). **(7)**

Map 5: The Saudi-Egypt Interconnector



Source: MEES

The Saudi Arabia-Egypt initiative marks the inaugural large-scale HVDC interconnection within the Middle East and North Africa region and it is estimated at $1.8 billion. The endeavor involves the establishment of

two high-voltage substations in Saudi Arabia's Medina and Tabuk regions, as well as the "Badr" station located on the outskirts of Cairo, the capital of Egypt. To ensure seamless connectivity, a network of 1,350 km-long overhead power transmission lines and 22 km of undersea cables spanning the Gulf of Aqaba will link the three substations.

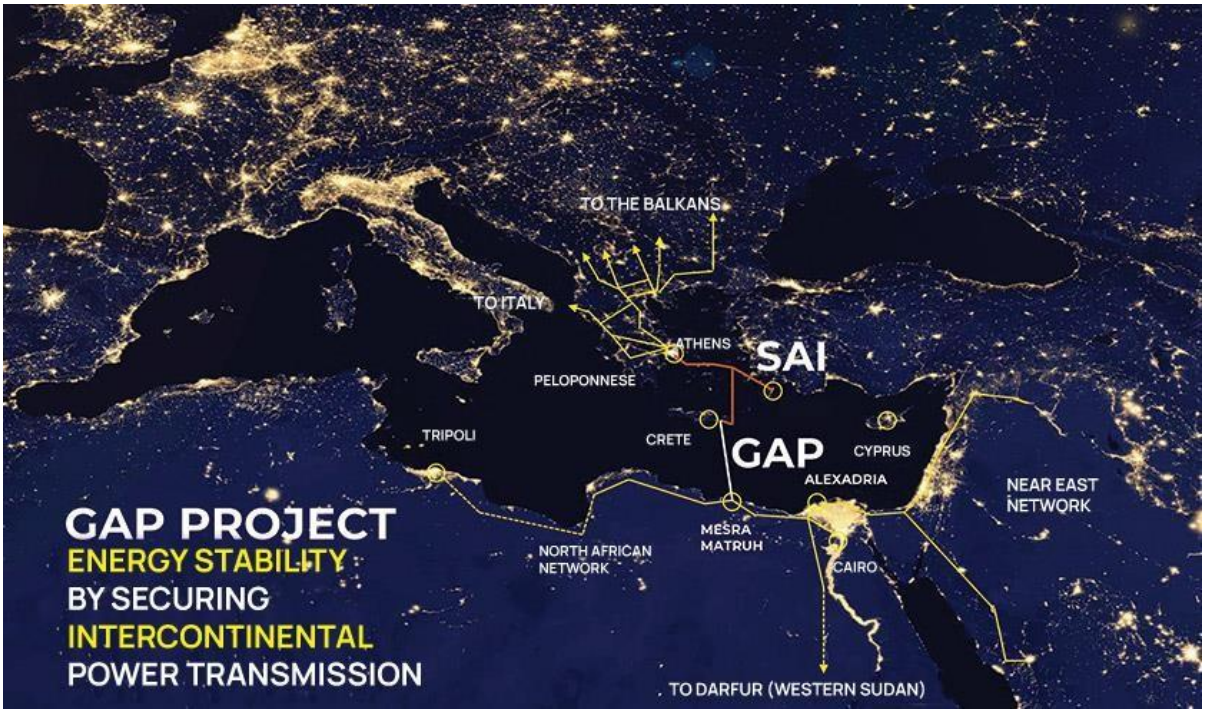
The contract for this undertaking was granted to a consortium comprising Hitachi ABB Power Grids from Japan and Saudi Services for Electro Mechanic Works (SSEM) in 2021. The contractual scope encompasses the implementation of three transformer stations in both Saudi Arabia and Egypt.

The project is set to unfold in two distinct phases. The initial phase, with a capacity of 1,500 MW, is scheduled to commence operation in July 2025 and subsequently, the second phase will kick off in November 2025, also boasting a capacity of 1,500 MW.

The Greece-Africa Interconnector

Another important electricity interconnection is the **Greece-Africa Power Interconnector**. The project, a proposal of the Eunice Group, includes the connection of South-Eastern Crete with Egypt and the extension of this interconnection to Attica as the most suitable option for the power interconnection of the two continents.

Map 6: Greece-Africa Power Interconnector



Source: Eunice Group

The Greece-Africa power interconnector project is among the projects that are gathering strong support from both sides of the Mediterranean and is included in the 2022 ten-year development plan of the ENTSO-E. The planned cable (2,000 MW) is characterised by significant advantages in terms of construction, geopolitical value, energy efficiency, economic viability, and potential for exploitation for the production of clean green energy. The project is expected to cost €1.3 billion, with a completion date of 2030, and will enable the bi-directional supply of electricity to Greece and Egypt.

The EuroGulf Interconnector

The EuroGulf Interconnector is yet another regional electricity project, which aspires to connect the Gulf Countries through Egypt and Cyprus with the European network of electricity grids, which are interconnected via bi-directional subsea DC cable and with HVDC onshore converter stations at each connection point, with a total capacity of 2,000 MW, to provide stable and sufficient electricity. This electricity highway can supply the European markets with electricity produced by gas reserves, as well as from the available RES and creates a reliable alternative route for the transfer of electricity between the Arabian Gulf countries and to/from Europe.

Map 7: The EuroGulf Interconnector

Source: EuroGulf-interconnector.com

The EuroGulf Interconnector is set to commence its journey from the vicinity of NEOM in Saudi Arabia. It will traverse the sub-sea path through the Red Sea and the Mediterranean, ultimately reaching Cyprus to establish a connection at the Kofinou station. Proceeding westward, it will follow a sub-sea route through mainland Greece, extending into Continental Europe. Spanning a total length of 747 km, the EuroGulf Interconnector will dip to its lowest sub-sea point, positioned at a depth of 3,000 meters below sea level.

These projects increase the green energy ambitions of a region that is still very dependent on hydrocarbons by creating hubs that help the countries concerned realize their RES potential and reduce their carbon footprint. They may also facilitate the transition to green energy for the countries involved. Combining interconnections with other technological innovations, such as creating an electricity highway and linking them to energy storage projects and RES investment in the region, would allow for optimal trade in energy across the European system, given the time differences between countries.

Map 8: Electricity Interconnections in SE Europe

Source: IPTO

Still, energy experts note that completing the integration of electricity networks in SE Europe will require sufficient long-term electricity storage projects and adequate cross-border and internal electricity interconnections.

The Case of Greece

In view of the fact that Greece's electricity grid has to support several island networks, of great significance are the developments regarding the electricity interconnections of the islands with the power grid in mainland Greece, and improved cross-border interconnections that will enable the national electricity transmission system to cover the requirements of the new targets for RES penetration and the incorporation of energy storage systems by 2030.

Indicatively, Greece's independent power grid operator (IPTO) has incorporated in its ten-year plan for the years 2024-2033 **(8)** the electricity interconnections of the North Aegean islands, the Cyclades and the Dodecanese. It is worth noting that Greece has electricity interconnections to Albania, North Macedonia, Bulgaria, Türkiye and Italy through a 400 KV connection. IPTO is now taking initiatives to upgrade Greece's interconnections with neighboring countries, acknowledging transboundary grid link insufficiencies are having a negative impact whose consequences include market functional disorders and higher electricity prices.

IPTO has formed working groups with all of Greece's neighboring countries to examine the prospect of constructing and reinforcing existing interconnections. More specifically, **Italian** operator Terna has signed a terms of reference agreement with IPTO for a new interconnection, with four development phases. The goal is to increase capacity with a 1 GW high-voltage direct current cable under the Ionian Sea from the existing 500 MW to 1,500 MW. The length of the new line is expected to reach 220 kilometers in the underwater segment plus another 55 kilometers on land. The existing Greek-Italian electricity grid interconnection, a 163 km subsea cable with a 500 MW capacity in operation since 2002, was useful in facilitating the Target Model's next stage, i.e. market coupling, beginning on December 15, 2020, with the aim of harmonizing the energy markets of the two countries. Now, an expansion and upgrade of the electricity interconnection between the two countries has become a top priority.

In addition, Greece and **Bulgaria** expanded their existing interconnection through the construction of a second line between Nea Santa and Maritsa East with a capacity of 2 GW and a length of 151 kilometers. The new 400 kV line is envisaged to increase the total capacity to 1.4 GW in the direction toward Bulgaria and to 1.7 GW from Bulgaria toward Greece. On June 30, 2023, electricity transmission through the new interconnection commenced, after the close cooperation of the competent personnel of the Transmission System Operators of the two countries for the start of the trial operation..

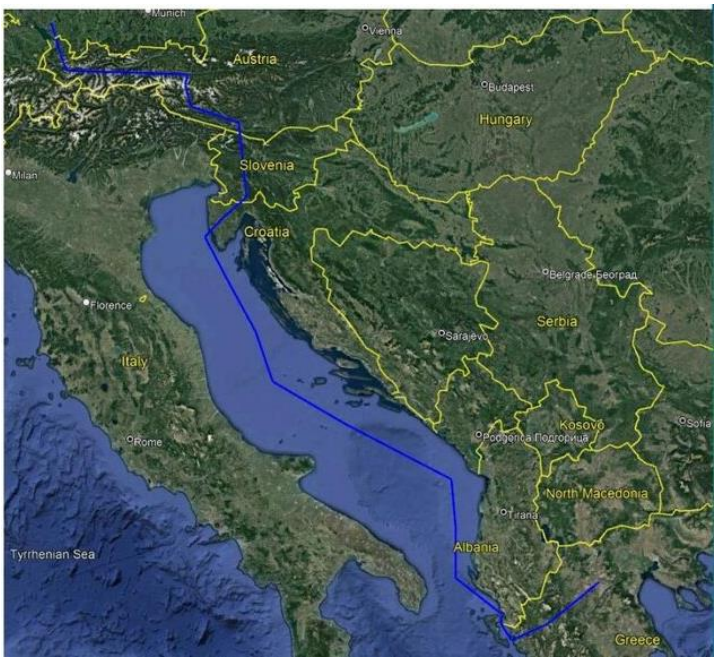
Another regional project is the second 400 kV interconnection between Greece and **Türkiye** to be completed by 2029. The 130-kilometer line will have a capacity of 2 GW, running parallel to the existing one. According to IPTO, the new interconnection will increase capacity by 600 MW in both directions and together with other new lines it will allow for increased RES penetration in the systems. With the forthcoming operation of Türkiye's new nuclear power plant in Akkuyu, the 1.1 GW first unit of which will go on stream later this year, Türkiye will be in a position to export higher volumes to Europe.

IPTO and **North Macedonia**'s transmission operator MEPSO intend to upgrade their interconnection after 2030. More detailed studies on the project are expected in the next few years, according to IPTO. Furthermore, IPTO and its **Albanian** counterpart OST have been in talks since 2020 on the possibility of building a second 400 kV interconnection. In February 2022, a working group was formed to examine the

technical aspects of the project. The goal is to connect Arachtos in Greece with Fier in Albania with a 145-kilometer cable. The line would increase capacity by at least 200 MW in both directions.

Moreover, Greece has proposed building a cable, known as the **Green Aegean Interconnector**, which will carry electricity mainly produced by RES to Austria and southern Germany where energy infrastructure is curbed by nature protection laws in the Black Forest region. According to Greek officials, the cable, which would have an initial capacity of 3 GW that could be ramped up to 9 GW, would run offshore through the Adriatic. The cable, which was included in the 2024 Development Procedural Plan by ENTSO-E in February 2024, would then run offshore through the EEZ of Albania, Montenegro, Croatia and Slovenia before reaching Austria and southern Germany. **(8)**

Map 9: The Green Aegean Interconnector



Source: IPTO

New interconnections in the Balkans are considered by the European Union and countries in the region as a vital step in order to ensure the security of supply in the future. It becomes even more urgent given the recent supply issues and the results of the energy crisis and expensive power and gas. Furthermore, both IPTO and other operators in the Balkans are focusing on the role of energy storage as a way to stabilize supply-demand and lead to an efficient power system in the years after 2030 within an environment of high RES penetration.

Table: Planned Electricity Interconnections in SE Europe, Including Greece

Project	Distance (km)	Capacity (MW)	Cost (€ million)	Company
EuroAsia Interconnector	1,208	2,000	2,400	EuroAsia Interconnector Ltd
EuroAfrica Interconnector	1,396	2,000	2,500	EuroAfrica Interconnector Ltd
Greece-Egypt Power Interconnector	954	3,000	4,200	ELICA SA
Greece-Africa Power Interconnector	420	2,000	1,300	GAP Interconnector S.M.S.A
Interconnector Greece-Italy	275	1,000	606	IPTO, TERNA
Interconnector Greece-Bulgaria	151	2,000	66	IPTO, ESO EAD
Interconnector Greece-Albania	145	2,000	15.3	IPTO, OST
Interconnector Greece-North Macedonia*	-	-	-	IPTO, MEPSO
Interconnector Greece-Türkiye	130	2,000	24.2	IPTO, TEIAS
Green Aegean Interconnector*	Through Albania, Montenegro, Croatia, Slovenia, Austria and southern Germany	3,000-9,000	-	-

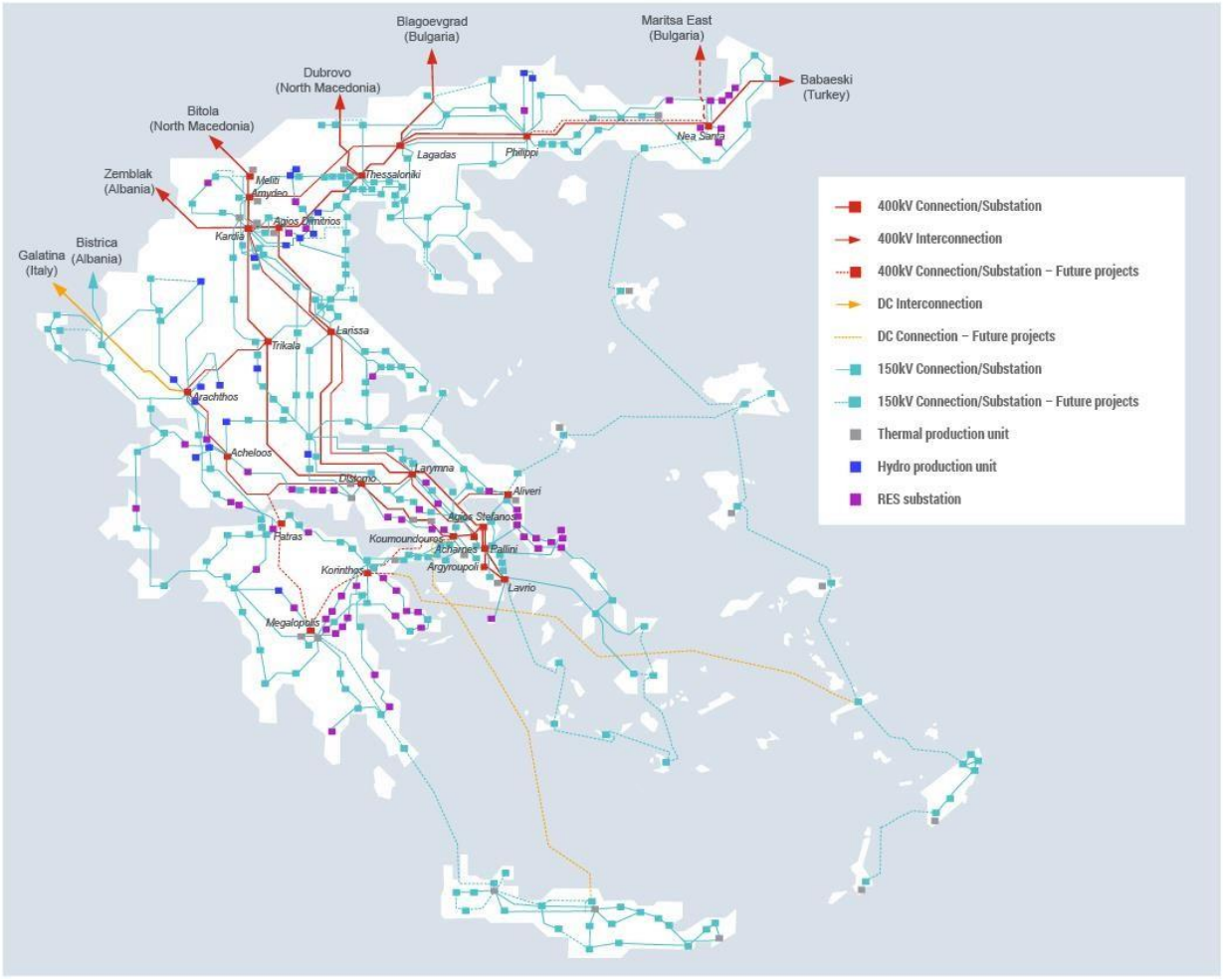
Note: *No more information and data are available.

Sources: Various websites, IENE

IPTO also continues to invest in the underwater connections of non-interconnected Greek islands. Currently, the fourth stage of the Cyclades interconnection is under way, while the operator also focuses on offshore wind planning in order to take advantage of the new connections and connect future wind farms in the Aegean. The Dodecanese (Kos-Rhodes-Karpathos-Samos) will be interconnected with the mainland system by 2028, while the Northeast Aegean islands (1st-3rd phase) are anticipated to be interconnected by 2029.

Regarding Crete's electricity interconnections, one of the most important milestones in the electricity interconnection project of Crete-Attica, i.e. the laying and installation of all the 500 kV direct current technology submarine cables, was successfully completed recently by IPTO's subsidiary company Ariadne Interconnection. The electricity interconnection of Crete with Attica is the largest energy investment, amounting to €1 billion, currently being carried out in the country, with which IPTO will fully integrate Crete into the continental electricity transmission system by the end of 2024. It should be noted that the small-scale grid interconnection to link Crete with the Peloponnese, with the longest in the world AC cable interconnection of 174 km, was completed in July 2021 and has been operational ever since.

Map 9: Domestic and Cross Border Electricity Interconnections in Greece



Source: IPTO

Discussion

As electricity interconnections increase in SE Europe, it is estimated that RES penetration and hence energy storage needs will rise. Combining interconnections with other technological innovations, such as creating an electricity highway and linking them to energy storage projects, such as pumped hydro and batteries and further investment in RES in the region, would allow for optimal trade in energy across the European system, given the time differences between countries.

Completing the integration of electricity networks in SE Europe will require both sufficient long-term electricity storage projects and adequate cross-border and internal electricity interconnections. Of great significance are the developments regarding the electricity interconnections of the islands with the mainland grid, such as in Greece, and improved cross-border interconnections that will enable the national electricity transmission system to cover the requirements of the new targets for RES penetration and the incorporation

of energy storage systems by 2030.

Currently, planned and under construction projects for cross-border electricity connections in SE Europe are critical both in preventing market congestion but also enabling the integration of electricity from RES and other sources. However, their impact will become more visible after 2028. In the case of islands, the use of hybrid plants with RES, i.e. RES and storage, is another solution in cases where the electricity interconnection to the mainland grid is not economically viable, but such plants will have to be assessed as to their technical and economic viability. Furthermore, they must be compared to the existing situation, and their installation and operation to be promoted only if it is ensured that power generation costs are reduced.

The construction of new electricity lines and interconnections, along with new gas pipelines, will enhance Greece's position as an important energy transit country and regional energy player. Such expanded energy network, including most of the islands, will undoubtedly help Greece to strengthen its sovereignty over its land and sea areas.

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3, Alex. Soutsou st. 106 71 Athens, Greece, T: +30-210 3628457, 3640278, F: +30 210 3646144, marketing@iene.gr, www.iene.eu